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ABSTRACT

Since weather plays an important role in many ways in our everyday life, the study of meteorological phenomena by school children becomes of great importance in enhancing their scientific literacy. This necessity becomes even more important today, as these phenomena are connected to serious environmental problems such as climate change and air pollution. The reported research deals with the investigation of children's conceptions about the movement of air masses in the troposphere, as this movement constitutes an important factor in the generation of the meteorological phenomena and the dispersion of air pollutants. Thirteen children from 12 up to 18 years old were interviewed by using a semi-structured questionnaire. From the analysis of their answers, it was found that the children of all ages had difficulties in explaining the mechanisms of movement of air masses in troposphere. Moreover, it was found that they held many misconceptions concerning the role of science concepts such as density, pressure, temperature, heat, and forces in connection with the motion of air masses in the troposphere. Also, it was found that, in their explanations, they don't use knowledge taught in school, and the construction of their ideas about these issues was influenced by their sensations, the mass media, as well as utilitarian considerations. (Contains 13 references.) (Author/YDS)

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A Cross-Age Study of Pupils' Conceptions Concerning the Movement of Air Masses in the Troposphere

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ABSTRACT

Since weather plays an important role in many ways in our everyday life, the study of meteorological phenomena by school children becomes of great importance in enhancing their scientific literacy. This necessity becomes even more important today, as these phenomena are connected to serious environmental problems such as climate change and air pollution. The reported research deals with the investigation of children's conceptions about the movement of air masses in the troposphere, as this movement constitutes an important factor in the generation of the meteorological phenomena and the dispersion of air pollutants. Thirteen children from 12 up to 18 years old were interviewed by using a semi-structured questionnaire. From the analysis of their answers it was found that the children of all ages had difficulties in explaining the mechanisms of movement of air masses in troposphere. Moreover, it was found that they held many misconceptions concerning the role of science concepts such as density, pressure, temperature, heat and forces in connection with the motion of air masses in the troposphere. Also, it was found that in their explanations they don't use knowledge taught in school, and that in the construction of their ideas about these issues, a vital role, played by their sensations, the mass media as well as a utilitarian consideration.

INTRODUCTION

For the last two decades it has been widely accepted by the science education community, that students hold ideas about science concepts prior to teaching which are usually inconsistent with scientific thinking. These initial ideas play a significant role in learning and for that reason they should be seriously taken into account in science teaching for meaningful learning to occur (i.e. Osborne, 1987, Driver, 1985). Today a considerable volume of research evidence exists on students' understanding for almost all areas of science.

An increasing number of these studies have been focused on pupils' understanding about the atmosphere, the climate, the meteorological phenomena in general (i.e. Stepans et al. 1985, Aron, et al 1994, Spiropoulou et al., 1999). Part of this research con-

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cerns pupils' understanding of environmental problems connected to the atmosphere such as global warming, acid rain and ozone layer depletion (cf. Dove, 1996; Rye et al, 1997; Boyes et al, 1993). Dove (1998) and Henriques (2000) reviewed the research into students' alternative conceptions about these phenomena. According to research evidence it seems that concepts relating to weather are constructed by children from their pre-school age and in this construction significant role is played by their senses, their fantasy, and expressions used by adults (Stepans et al. 1985). The research arrived also at conclusion that older children and adults have misconceptions too about the concepts and phenomena connected to meteorology (Nelson et al, 1992) which, among others, may have to do with inadequate ways of teaching about these at school.

Without any doubt teaching about meteorological phenomena is a difficult task, because these are very complicated systems and in advance, its understanding requires familiarisation with many science concepts such as the nature of gases, air pressure, dispersion, density, temperature, water cycle, etc. But, because of the significance of these phenomena in our everyday life, their study by school children becomes of great importance especially nowadays as these phenomena are connected to serious environmental problems such as climate change and air pollution. Thus, it is a challenge for educators to search for more proper ways of teaching about these phenomena and being aware of students' misconceptions they can invent effective methods for teaching.

The reported research constitutes the first step of a larger project aiming at the investigation of pupils' conceptions about the atmosphere, and the meteorological phenomena in connection with air pollution and climate change. We hope that the research findings will offer us an insight into students' thinking so as by taking this into account, we will be able to make suggestions which may help teachers in teaching about these issues.

BACKGROUND AND PURPOSE

In Greece, up to know, topics connected to meteorology are mainly taught in the primary and lower secondary school but not in the upper secondary school. Topics taught are: the structure of the atmosphere, the atmospheric pressure, the weather, climate and seasons, wind, water cycle, air pollution and its consequences. These topics are taught through Ggeography and Science.

A serious problem has to do with the ways these topics are taught. The Greek educational system is a strictly centralized and the school curricula are uniform, which means that not only are the same subjects taught but also the same contents, in the same order and also the same books are used in all schools. Teaching in all subjects has a theoretical character, takes place inside the classroom and even in science teaching children are not engaged in practical work. This is expected to have consequences in pupils' understanding in all areas of science including the topics connected to meteorology.

Many of the science concepts involved in the topics concerning the meteorology

such as, the properties of gases, temperature, pressure, dispersion are also taught through science lessons but usually without making connections to these phenomena. In some cases these phenomena are taught before children have heard anything about the science concepts involved.

The study reported herein examined the different age children's perceptions a) about the movement of air masses in the troposphere and b) about the wind. The focus was the troposphere, as the movement of gases in this atmospheric layer is firmly connected, on the one hand with climate formation and on the other with the diffusion and the transportation of air pollutants.

This research conducted at the end of the school year and our main interest was to find out if pupils in explaining these phenomena use science knowledge that had been taught. We also included in our sample school leavers (18 years old) who as already mentioned had not been taught about meteorology during their study at the upper secondary school but they had been taught some of the involved science concepts.

SAMPLE AND METHOD

Thirteen pupils aged 12 to 18 years old constituted the sample of our research. More specifically:

3 pupils 12 yeas old (6th form of the primary school),

2 pupils 13 yeas old (1st form of the lower secondary school)

2 pupils 14 yeas old (2nd form of the lower secondary school)

3 pupils 15 yeas old (3rd form of the lower secondary school) and

3 pupils 18 yeas old (graduates of the upper secondary school).

These pupils interviewed by the use of semi-structured questionnaires. The questions had the same subject – matter but they were tailored to pupils' age and also to their responses in the previous questions. They were also asked to draw some pictures in order to illustrate their answers. Each interview lasted 15 minutes and was tape-recorded. We chose interview as the more effective methodology given that it helps in gaining an insight into pupils' way of thinking which we hope will guide us in the bigger scale research we plan for the future.

RESULTS AND DISCUSSION

As already mentioned the meteorological phenomena are complicated systems and many aspects concerning them are not even known to specialists. So we cannot expect school children to know all about these but what is needed is just some basic knowledge which will help them understand the way these affect their everyday life. Simplified scientific views concerning the issues under investigation can be summarised as follows: Air masses in the troposphere move, on the one hand because of the diffusion and on the other, by the creation of the wind. The movement of air masses may be horizontal

or vertical. Horizontal movement (surface wind) always happens because of differences in pressure and temperature. The direction is from the low temperature and consequently of high pressure areas to high temperature and low pressure areas (Schlenker & Perry, 1981). Apart from the horizontal movement there is also the vertical one (air currents), downward and upward. A factor that also plays a significant role in the movement, is the topography. As more ruffles is land's surface as much turbulence and air dispersion takes place and so the vertical movement is easier (Cole, 1973). Also it is known that temperature inversions prevent vertical motion of air masses (Campbell & Gimps, 1975).

Children's conceptions about the movement of gases in the troposphere

In order to find out about pupils thinking concerning the motion of gases in the troposphere, we started interviewing pupils by asking the following questions: (a) Do you think that the gases that exist in the troposphere move? (b) If you think so, to which direction this movement takes place? And (c) what causes this movement?

We have to mention here that before starting the discussion with pupils it was made clear that troposphere is called the lower layer of the atmosphere.

From the analysis of children's responses to the first two of these questions it was found out that children of all ages were aware of the movement of gases in the troposphere and of the fact that this movement occurs to all directions. Concerning the causes of that movement, from their answers to the third of the above questions, it seems that they regard the wind as the cause of that movement which means that they think of it as something different from movement of air masses. The same was identified later on, when they were asked about the wind and its generation. Nobody mentioned the diffusion. Only three pupils, two from second form of lower secondary school and one graduate of the upper secondary school, mentioned the verb "*spread*" but again they added the phrase "*with the wind*". The explanations they offered come probably from their sense experience, as the wind is something that they feel through their senses.

In our effort to have a deeper insight in children's thinking concerning the motion of gases in the troposphere, in the course of the interview, they were asked if they thought that among the directions the gases follow in their movement the vertical and the horizontal were included. After their positive answer to this question, they were asked to explain the causes of these movements.

From their answers it was found that all children with no exception, believe that the gravity is the determining factor that causes the vertical motion of gases of the troposphere. According to what they say it seems that they separate gases of the troposphere in heavy and light. Some typical answers run as follows:

"heavy gases go down and the lighter go up"

"the light gases go up and the heavier go down"

"gases move vertically because of the gravity".

It also seems that this view is firmly hold in their mind as one can judge from the following dialogue. In the mind of this child the gravity plays so important role in motion that he precludes the horizontal motion of gases.

Quest. "Why gases go up? What causes this movement?"

Ans. "Because they are lighter"

Quest. "Does atmospheric air go down?"

Ans. "Yes, if gases are heavier. Yes"

Quest. "Does it happen horizontal movement?"

Ans. "I don't think so"

These conceptions concerning the role of gravity in motion of gases show that children hold misconceptions about the properties of gases. Other researchers too (Nelson et al, 1992) found that even university students in geography consider gravity as the only factor determining the movement of gases in the atmosphere.

Children's conception about wind and its generation

In this part of our research we focused in finding out: a) what pupils think about the wind and b) what explanations they give concerning the generation of the wind.

We have to mention here that pupils actually had taught about the wind and its generation in the 6th form of the primary school and also in the 1st and 2nd form of the low secondary school. In their textbooks it is mentioned the role of the temperature and pressure in the generation of the wind and also the role of the topography. Also they have taught about horizontal and vertical movement of air masses.

Views about the wind

Firstly pupils asked the question: What do you think the wind is all about? Apart from those who answered "I do not know", the answers of the rest fall into four categories which are presented in the Table 1.

Characteristic answers that fall in each one of the four categories are the following:

1) Those that give a scientifically acceptable answer mentioning both the constitution of the wind and the movement.

"Movement of air masses"

"The wind has some gases; it is made up of some gases and these gases go fast to a direction"

1) Those that think of the wind as the cause of the movement of air masses

"Gases that move when it blows"

"Movement of air masses occurs when air blows"

2) The majority described the wind mentioning properties perceived rather through their senses.

"The wind has a great force. It moves".

"Something that blows"

"The currents that exist in the environment"

3) Irrelevant overgeneralized answers: *"In my opinion it is a physical phenomenon"*

Table 1: Students' views about the wind

Categories of answers	Number of children divided in different ages				
	Primary school (3)	1st form of lower sec. school (2)	2nd form of lower sec. school (2)	3rd form of lower sec. school (3)	Upper sec. school graduates (3)
Scientifically acceptable answers		1		2	1
Think of the wind as the cause of the movement of air masses			1		1
Describe the wind mentioning properties perceived through their senses	1	1	1		1
Irrelevant answers	1				
No answer	1			1	

Views about the causes generating the wind

Children's responses to the second question in this part of our research concerning their explanations about the causes of the generation of the wind are summarised in Table 2.

Table 2: Students' answers in question about the causes of the generation of the wind

Categories of answers	Number of children divided in different ages				
	Primary school (3)	1st form of lower sec. school (2)	2nd form of lower sec. school (2)	3rd form of lower sec. school (3)	Upper sec. school graduates (3)
Connection with pressure and temperature				1	
Connection only with pressure			1		
Connection only with temperature		1			1
Connection with force	1		1		
Other answers	2			2	
No answer		1			2

As one can see from the table 2, only one child (3rd form of lower sec. School) relate the generation of wind to both pressure and temperature. In his words:

"Warm air masses go up because the warmer they are the lighter they getting and so air blows upwards. As air masses go up, they become cold, and thus heavier and then air masses go down. The wind also flows from high pressure to low".

Two children (one from 1st form of lower secondary school, and one of upper sec-

ondary school graduate), relate the wind to differences in temperature. In their answers they said that there is a movement of gases from low temperature areas to high temperature areas and they connect this motion with "north wind". From the answer given by the upper secondary school it seems that the TV weather forecasts play a significant role in constructing their views about the generation of the weather.

"As we hear on T.V news, on weather forecast, a warm stream of air will come from Africa and after a few days we have hot weather. Then they announce that a cold steam of air will come from North Pole and after that we have cold weather".

One student mentioned the pressure but it seems that he confuses it with the force. In his words: *"The wind is caused because of a pressure. This pressure forces the wind with a press to go to a direction. It will be pressed. The most it is pressed the more it blows, the least it is pressed the less it blows"* (2nd form of lower sec. school).

Two students, one from the 6th form of primary school and one from the 2nd form of lower secondary school mention the force. They talk about attractive force or force caused by heat.

"Some air masses attract others and so it creates the wind" (pupil from the 6th form of primary school).

"The wind has a big force. Heat pushes it. The heat has also a great force" (2nd form of lower sec. school).

The rest seven pupils, gave irrelevant answers or said: *"I don't know".*

In conclusion, it seems that although pupils have taught in school about the role of pressure and temperature in the generation of the wind, finally their senses and weather forecasts on TV affect them in constructing their own views. It is also significant to mention the identified misconceptions such as confusing the air pressure with force and force with heat.

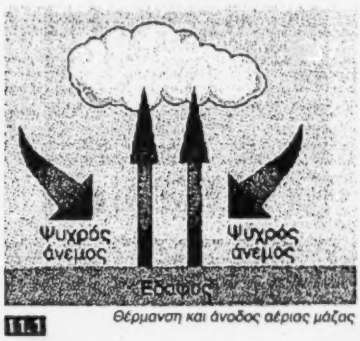

Fig. 1. Air movement between warm area and colder area nearby presented in school textbook.

In order to find out more about the impact had in their understanding, knowledge taught in school about the mechanisms the wind is generated, we asked them to draw a picture showing the directions of the wind between a town which is warm and the cold countryside nearby. They also asked to give some explanations. Taken into account that such pictures followed by explanations concerning the directions that air masses follow are contained in many of their science and geography textbooks for both primary and lower secondary school. In detail it is explained the role that pressure, temperature and density play in the generation of the upward currents, the downward currents and the surface wind.

By examining children's pictures, we identified that only in four of these the circular motion of the air masses between the warm city and the cold suburb is represented. From these pictures one drawn by a primary school pupil, two by 3rd and one by 2nd form of the lower secondary school pupils.

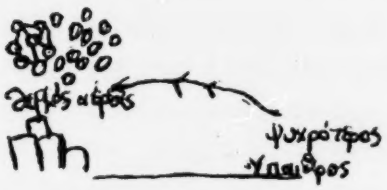

Fig. 2a. 1st form of low sec. school student's picture.

Fig. 2b. Primary school student's picture.

In another four pictures only the surface wind to one direction, from the country to the town or the reverse, is represented (Figure 2a, 2b). Finally in two pictures (drawn by upper secondary school graduates) surface wind is also represented as air current coming from opposite directions (Figure 2c).

Three children refused to draw anything with the excuse that they didn't know.

Concerning the explanations they gave about the causes of the movement present-

ed in their pictures it was found that from the four children that drew the circulate motion only two student both in third form of lower secondary school were able to give explanations close to the scientific view. For instance by saying that *"the warm air goes up and by that it is getting colder, heavier and thus it goes downward"*. It seems that the mechanistic way of learning in their mind leaves only the figure of this motion but not the necessary scientific explanations.

The fact that, in all children's explanations concerning the causes of the movement of air between the city and the suburb, a utilitarian view is prevailing came as a surprise to us. They think that movement takes place under the necessity of "cleaning" the town of pollutants and bringing fresh, clean air from the countryside. Some of their answers are the following:

"The wind transports pollution from the town to the countryside, or clean and cold wind from country comes to the town so the town is getting clean" (pupil from primary school).

"The pollution from factories and vehicles causes the increase of temperature in the city so the wind from the city to the country takes the pollution from the city to the country, from hot place to the cold one." (pupil from 3rd form of lower sec. school).

The utilitarian view is more apparent in one upper sec. school graduate's response that seems to believe that air masses move in order to clean the polluted atmosphere of the city and its direction depends on the degree of air pollution of the city and the countryside.

"I believe that air masses go only from the city to the country. I don't know how exactly, it depends on the air pollution that is produced in the country, if there are factories there. If air above suburb is cleaner than above city I believe that, only in that case, air pollution from city will be transferred to suburb" (upper sec. school graduate).

This utilitarian consideration apart from not being compatible with the scientific views, may have an impact on pupils attitudes to the environment. They may think that people who live in the city can pollute as pollution disappears by the wind.

CONCLUSIONS AND IMPLICATIONS

Findings drawn from this small scale research concerning pupils' conceptions can be summarised as follows:

- Pupils of all ages, included in the sample, are aware of the movement of gases in the troposphere and of the fact that this movement occurs to all directions.
- PThe majority of pupils, independently of their age, separate gases into heavy and light and regard the gravity as the main factor of determining the vertical motion of gases.
- PMany of them regard the wind as something different from movement of air masses. They actually believe that the wind is the cause of that movement.

- Some describe the wind by mentioning properties perceived through their senses rather than using scientific terms taught in school.
- Pupils of all ages hold misconceptions concerning science concepts, such as the properties of gases, they confuse the pressure with the force and the heat with the force.
- The TV weather forecasts play a significant role in constructing their views about the generation of the weather.
- Their views concerning the movement of air masses between a city and the nearby countryside are guided mainly on the bases of a utilitarian consideration having to do with the transfer of pollution.
- In general we did not identified considerable differentiation in pupils' conceptions about the issues under investigation following the increase of their age. In the contrary in many cases younger children were more accurate in their responses than the older ones. It seems that further they are from the teaching about this theme the less they know about it. This is probably due to learning by rote, which is in fact the common practice in Greek schools.

These findings should be seriously taken into account in teaching about issues concerning the atmosphere, the weather, the climate, and air pollution. The content taught should be suitable for pupils' age avoiding the science concepts, which have not so far being taught. It would be of vital importance the use of these themes as contexts for teaching the science concepts involved. Also, involving pupils in practical work should be included in teaching and the use of new technologies will be an attractive way for learning and may contribute to better understanding. If the understanding of these important themes connected to the atmospheric phenomena, must constitute part of adults' scientific literacy, then teaching about them should not just stop at the level of the lower secondary school, but it must also be part of the upper secondary school curriculum.

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